CLAIMS

1. A phase contrast system for synthesizing an intensity pattern I(x', y'), comprising

a source of electromagnetic fields for emission of at least two substantially plane electromagnetic fields with different axes of propagation,

a phase modifying element for phase modulation of the electromagnetic fields by phasor values $e^{i\phi(x,y)}$ and positioned so that the at least two electromagnetic fields are incident upon it at different respective angles of approach,

first Fourier or Fresnel optics for Fourier or Fresnel transforming the phase modulated electromagnetic fields positioned in the propagation paths of the at least two phase modulated fields,

a spatial phase filter with at least two phase shifting regions positioned at respective zero-order diffraction regions of the at least two respective phase modulated electromagnetic fields for individually phase shifting the at least two respective Fourier or Fresnel transformed electromagnetic fields by predetermined respective phase shift values θ_n in relation to the remaining part of the at least two respective transformed electromagnetic fields, and

second Fourier or Fresnel optics for forming the intensity pattern I(x', y') by Fourier or Fresnel transforming the at least two respective phase shifted Fourier or Fresnel transformed electromagnetic fields,

c h a r a c t e r i z e d in that

the phasor values $e^{i\phi(x,y)}$ of the phase modifying element and the phase shift values θ_n substantially fulfilling that

$$I(x',y') \cong \sum_n S(n)A^2 \left|\exp\left(i\tilde{\phi}(x',y')\right) + K_n \left|\bar{\alpha}\right|\left(B_n A^{-1}\exp\left(i\theta_n\right)-1\right)\right|^2$$

for selected phase shift values θ_n,

wherein

A is an optional amplitude modulation of the spatial phase filter outside the zero-order diffraction regions,

B_n is an optional amplitude modulation of the spatial phase filter in the respective n'th zero-order diffraction region,

$\bar{\alpha} = |\bar{\alpha}| \exp(i\phi_{\bar{\alpha}})$ is the average of the phasors $e^{i\phi(x,y)}$ of the resolution elements of the phase modifying element, and

$\tilde{\phi} = \phi - \phi_{\bar{\alpha}}$, and

$S(n)$ is the intensity of the n'th electromagnetic field, and

$K_n = 1 - J_0(1.22\pi\eta_n)$, wherein

J_0 is the zero-order Bessel function, and

η_n relates the radius R_{1n} of the n'th zero-order filtering region to the radius R_2 of the main-lobe of the Airy function of the input aperture, $\eta_n = R_{1n} / R_2$,

except

when the phase modifying element has fixed phasor values $e^{i\phi(x,y)}$ and

1) $\theta_n = \frac{\pi}{2}$ and the phase shifting area of the phase filter is annular, or,

2) $\theta_n = \pi$ and the phase filter is divided into a plurality of rows, every second row having phasor value $e^{i\pi}$ and being interlaced with the remaining rows having the phasor value e^{i0}.

2. A phase contrast system according to claim 1, wherein the phase modifying element has an input for reception of signals for addressing the resolution elements (x, y) and for adjusting the phasor values $e^{i\phi(x,y)}$ of the respective addressed resolution elements (x, y).

3. A phase contrast system according to claim 2, further comprising a controller with a first output that is connected to the input of phase modifying element, and a second output that is connected to the spatial phase filter and being adapted for adjusting phasor values $e^{i\phi(x,y)}$ of the phase modifying element and phase shift values θ_n of the spatial phase filter.

4. A phase contrast system according to claim 2, wherein the controller further comprises a user interface and being adapted for adjusting phasor values $e^{i\phi(x,y)}$ of the phase modifying element and phase shift values θ_n of the spatial phase filter in accordance with user inputs.

5. A phase contrast system according to any of the preceding claims, wherein the phase shifting regions of the spatial phase filter form a rectangular array.

6. A phase contrast system according to any of claims 1-4, wherein the phase shifting regions of the spatial phase filter form a circular array.

7. A phase contrast system according to any of claims 1-4, wherein the phase shifting regions of the spatial phase filter form a linear array.

8. A phase contrast system according to any of claims 1-4, wherein the phase shifting regions of the spatial phase filter form two linear crossing arrays.

9. A phase contrast system according to any of the preceding claims 1, wherein the phase shifting regions form a continuous region.

10. A phase contrast system according to claim 9, wherein the phase shifting regions of the spatial phase filter form a ring.

11. A phase contrast system according to any of claims 1-4, wherein the phase shifting regions of the spatial phase filter form an arbitrary array.

12. A phase contrast system according to any of the previous claims, wherein

$$A = 1.$$

13. A phase contrast system according to any of the previous claims, wherein

$$B_n = 1.$$

14. A phase contrast system according to any of the previous claims, wherein

$$\theta_n = \pi.$$

15. A phase contrast system according to any of the previous claims, wherein

$$K_n = 1.$$

16. A phase contrast system according to any of the previous claims, wherein the source comprises a plurality of light sources.

17. A phase contrast system according to any of the previous claims, wherein the source comprises a laser array, such as a VCSEL array.

18. A phase contrast system according to any of the previous claims, wherein the source comprises a light scanner for time multiplexed emission of the at least two substantially plane electromagnetic fields with different axes of propagation.

19. An optical tweezer system according to any of the previous claims.

20. An optical tweezer system according to any of the previous claims, wherein the synthesized intensity pattern forms a set of non-interfering counter propagating beams.

21. A laser machining tool according to any of the previous claims.

22. A method for synthesizing an intensity pattern $I(x', y')$, comprising the steps of

dividing the intensity pattern I(x',y') into pixels in accordance with the disposition of resolution elements (x,y) of a phase modifying element having

a plurality of individual resolution elements (x,y), each resolution element (x,y) modulating the phase of electromagnetic radiation incident upon it with a predetermined phasor value $e^{i\phi(x,y)}$,

radiating at least two substantially plane electromagnetic fields with different axes of propagation towards the phase modifying element so that the at least two electromagnetic fields are incident upon it at different respective angles of approach,

Fourier or Fresnel transforming the phase modulated electromagnetic fields,

phase shifting in at least two phase shifting regions positioned at respective zero-order diffraction regions of the at least two respective phase modulated electromagnetic fields for individually phase shifting the at least two respective Fourier or Fresnel transformed electromagnetic fields by predetermined respective phase shift values θ_k in relation to the remaining part of the at least two respective transformed electromagnetic fields, and

forming the intensity pattern I(x', y') by Fourier or Fresnel transforming the at least two respective phase shifted Fourier or Fresnel transformed electromagnetic fields,

calculating the phasor values $e^{i\phi(x,y)}$ of the phase modifying element and the phase shift values θ_n substantially in accordance with

$$I(x',y') \cong \sum_n S(n)A^2\left|\exp\left(i\tilde{\phi}(x',y')\right)+K_n\left|\bar{\alpha}\right|\left(B_nA^{-1}\exp\left(i\theta_n\right)-1\right)\right|^2$$

for selected phase shift values θ_n, wherein

A is an optional amplitude modulation of the spatial phase filter outside the zero-order diffraction regions,

B_n is an optional amplitude modulation of the spatial phase filter in the respective n'th zero-order diffraction region,

$\bar{\alpha}=\left|\bar{\alpha}\right|\exp\left(i\phi_{\bar{\alpha}}\right)$ is the average of the phasors $e^{i\phi(x,y)}$ of the resolution elements of the phase modifying element, and

$\tilde{\phi}=\phi-\phi_{\bar{\alpha}}$, and

$S(n)$ is the intensity of the n'th electromagnetic field, and

$K_n=1-J_0\left(1.22\pi\eta_n\right)$, wherein

J_0 is the zero-order Bessel function and

η_n relates the radius R_{1n} of the n'th zero-order filtering region to the radius R_2 of the main-lobe of the Airy function of the input aperture, $\eta_n = R_{1n} / R_2$.

selecting, for each resolution element, one of two phasor values which represent a particular grey level, and

supplying the selected phasor values $e^{i\phi(x,y)}$ to the respective resolution elements (x, y) of the phase modifying element.